Shock history analysis of the space material based on the coercivity distribution of the remanent magnetization. T. Kohout[1, 2, 3], G. Kletetschka[3, 4, 5] and L. J. Pesonen[1], [1]Division of Geophysics, Faculty of Science, University of Helsinki, Finland, e-mail: tomas.kohout@helsinki.fi, [2]Department of Applied Geophysics, Faculty of Science, Charles University in Prague, Prague, Czech Republic, [3]Institute of Geology, Academy of Sciences of the Czech Republic, Prague, Czech Republic, [4]Catholic University of America, Washington, D.C., USA. [5]NASA-GSFC, Greenbelt, Maryland, USA.

Introduction:

The extraterrestrial material can carry remanent magnetization of the space origin. The possible space magnetizing processes can be TRM (Thermo-Remanent Magnetization - generated as the material is cooling through its blocking temperature in the presence of ambient magnetic field), CRM (Chemo-Remanent Magnetization – generated as the mineral grain is growing through its blocking size in the presence of ambient magnetic field) or IRM (Isothermal Remanent Magnetization – generated by exposure to strong ambient magnetic field at temperatures lower than blocking). The ambient magnetic field can be represented by the solar magnetic field, magnetic field generated in cores of planetesimals and planets or by the lightnings in the early solar nebula.

Shock history analysis technique:

The magnetized space material can be later exposed to various shock events (impacts, collisions, Hayabusa type sampling procedure) which have significant demagnetization effect. The efficiency of the impact demagnetization depends on the mineral grain size. The large, multi-domain, low coercivity grains demagnetize much effectively than the small, single domain high coercivity ones. Thus the coercivity spectra analysis of the remanent magnetization can reveal the evidence for the shock history.

In order to analyze the coercivity spectra of studied material and evaluate the shock demagnetization level the method based on REM(AF) ratio is applied [1]. The technique utilizes a detailed AF demagnetization of NRM (Natural Remanent Magnetization), followed by demagnetization of the SIRM (Saturation Isothermal Remanent Magnetization) in the very same AF demagnetization steps.

The slope of the REM(AF) curve (fig. 1) contains the information about the origin and history of the NRM. The constant REM(AF) ratio represented by flat curve is typical for TRM or CRM. The shock demagnetization will result in the REM (AF) curve with positive slope (low coercivity grains are demagnetized more progressively, fig. 1). The REM(AF) curve with negative slope represents the NRM with viscous or artificial overprint and thus not suitable for this study.

Experimental verification:

The method was tested on chondrules (~1 mm in diameter) from Avanhandava H5 chondrite. The chondrules were first magnetized in the laboratory (SIRM) and then shocked with the ~1 GPa shock pressure in the controlled ambient field (<500 nT). The shocked material was than analyzed using the described technique. The REM(AF) ratio shows positive slope indicating the shock demagnetization.

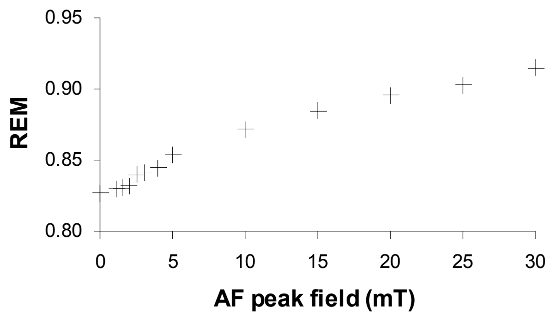

Figure 1: The analysis of the laboratory shock experiments on the chondrule from Avanhandava H5 chondrite reveal the positive slope of the REM (AF) curve as a result of the ~1 GPa shock.

Conclusions:

The method can be used for identification of the shock history of space materials (chondrules, meteorites, sample returns). Both natural (impacts, collisions) and artificial (Hayabusa type sampling procedure) shock events can be identified. The efficiency of the shock demagnetization is material dependent and thus must be calibrated for each rock type.

References:

[1] Kletetschka G., Kohout T., Wasilewski P. J. and Fuller M. (2005) 10th Scientific Assembly of the International Association of Geomagnetism and Aeronomy, Toulouse, France, IAGA2005-A-00945, p. 53.